MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EME1026 – FLUID MECHANICS

(ME)

16 OCTOBER 2017
2:30 p.m. – 4:30 p.m.
(2 hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of SEVEN pages including cover page.
2. There are FOUR questions in total.
3. Attempt **ALL** questions. All questions carry equal marks.
4. Please write all your answers in the Answer Booklet provided.

Question 1

Figure Q1 shows a pipe is attached to a horizontal tee. Water is flowing as two free jets from the tee with an exit speed of 20 m/s. The density of water is given as 1000 kg/m^3, gravity and viscous effects are negligible.

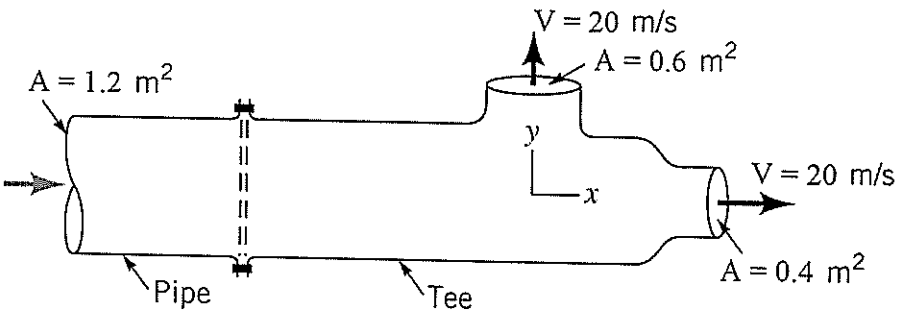

Figure Q1

(a) Sketch the control volume of the horizontal tee and analyse all the possible force components acting on the horizontal tee. **[5 marks]**

(b) Formulate the x and y-components of the linear momentum equation based on the sketched control volume from **part (a)**. **[6 marks]**

(c) Determine the pressure, velocity and mass flow rate at the tee inlet. **[9 marks]**

(d) Determine the x and y-components of the force required to hold the tee in place. **[5 marks]**

Continued...

Question 2

A blood artery in a human's body has a diameter of 9 mm and a length of 0.35 m. The blood flow is unidirectional with a flow rate of 0.001 m^3/min. Consider the blood flow is steady with viscous effect. The density and dynamic viscosity of the blood are given as 1060 kg/m^3 and 0.004 Ns/m^2, respectively.

(a) Form an energy equation for the blood artery. Assume the artery with constant diameter is oriented horizontally. Simplify the equation. **[5 marks]**

(b) Determine the Reynolds number and justify if the blood flow is laminar or turbulent. **[7 marks]**

(c) Calculate the friction factor of the blood flow. **[3 marks]**

(d) Determine the pressure drop needed to force the blood through the blood artery. **[3 marks]**

(e) Sketch the blood artery and analyse the relevant force components acting on the blood artery. Apply the Newton's second law to derive the shear stress equation. Determine the shear stress acting on the artery wall. **[7 marks]**

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Question 3

(a) The pressure drop Δp along a straight pipe of diameter D has been experimentally studied, and it is observed that for laminar flow of a given fluid and pipe, the pressure drop varies directly with the distance ℓ, between pressure taps. Assume that Δp is a function of D and ℓ, the velocity V, and the fluid viscosity, μ. Use dimensional analysis to deduce how the pressure drop varies with pipe diameter.

[15 marks]

(b) A model of a submarine, 1:15 scale, is to be tested at 55 m/s in a wind tunnel with standard sea-level air, while the prototype will be operated in seawater. Determine the speed of the prototype to ensure Reynolds number similarity. The given kinematic viscosity of sea-level air is 1.46×10^{-5} m^2/s and seawater is 1.17×10^{-6} m^2/s.

[10 marks]

Continued...

Question 4

A centrifugal pump impeller is rotating at 1200 rpm in the direction shown in **Figure Q4**. The flow enters parallel to the axis of rotation and leaves at an angle of 30° to the radial direction. The absolute exit velocity, V_2, is 28 m/s.

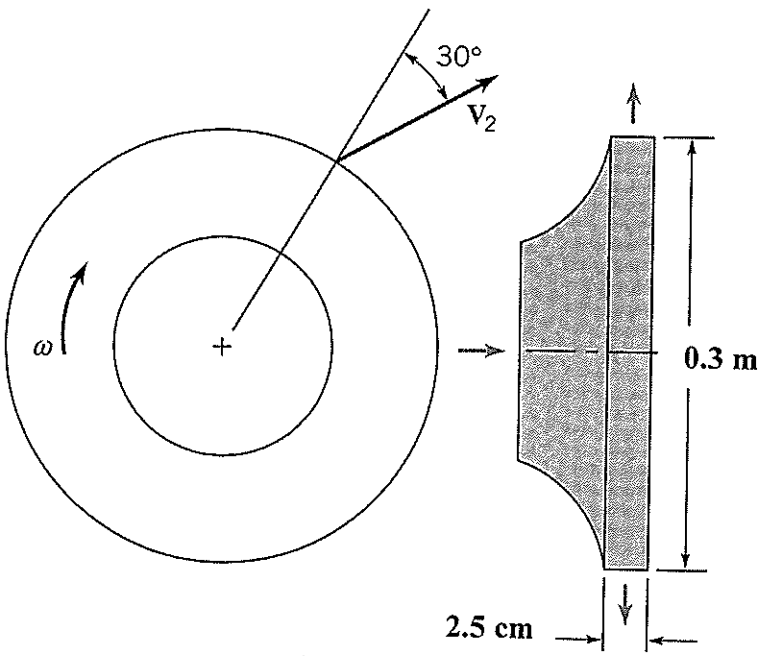

Figure Q4

(a) Draw the velocity triangle for the impeller exit flow and completely specify the velocity triangle.

[15 marks]

(b) Estimate the torque necessary to turn the impeller if the fluid is water.

[6 marks]

(c) What will happen to a pump if the shaft breaks?

[4 marks]

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APPENDIX 1: Friction factor for fully developed flow in circular pipes

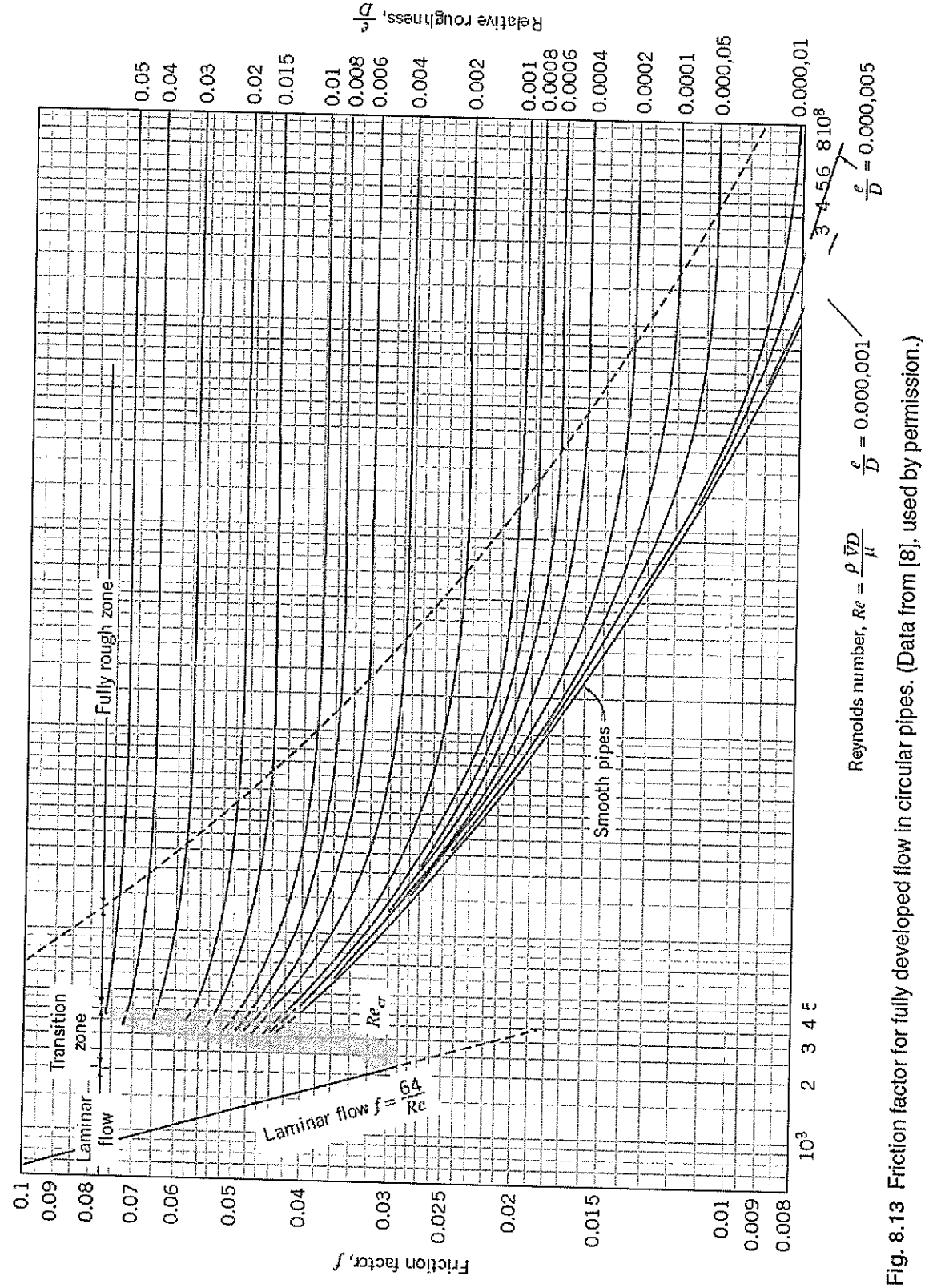

Fig. 8.13 Friction factor for fully developed flow in circular pipes. (Data from [8], used by permission.)

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APPENDIX 2: Physical Properties of Water

Temperature (°C)	Density, ρ (kg/m³)	Specific Weight[b], γ (kN/m³)	Dynamic Viscosity, μ (N·s/m²)	Kinematic Viscosity, ν (m²/s)	Surface Tension[c], σ (N/m)	Vapor Pressure, p_v [N/m²(abs)]	Speed of Sound[d], c (m/s)
0	999.9	9.806	1.787 E − 3	1.787 E − 6	7.56 E − 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E − 3	1.519 E − 6	7.49 E − 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E − 3	1.307 E − 6	7.42 E − 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E − 3	1.004 E − 6	7.28 E − 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E − 4	8.009 E − 7	7.12 E − 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E − 4	6.580 E − 7	6.96 E − 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E − 4	5.534 E − 7	6.79 E − 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E − 4	4.745 E − 7	6.62 E − 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E − 4	4.134 E − 7	6.44 E − 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E − 4	3.650 E − 7	6.26 E − 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E − 4	3.260 E − 7	6.08 E − 2	7.010 E + 4	1550
100	958.4	9.399	2.818 E − 4	2.940 E − 7	5.89 E − 2	1.013 E + 5	1543

[a]Based on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.
[b]Density and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 9.807$ m/s².
[c]In contact with air.
[d]From R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

APPENDIX 3: Equivalent roughness in circular pipe

Pipe	Equivalent Roughness, ε Feet	Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)

End of paper